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FABRICATION AND TESTING OF
SCATTER PLATES FOR INTERFEROMETRY

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16. ABSTRACT Scatter plate interferometry has become a reliable method of measuring surface configurations of telescope mirrors and other optical components. The scatter plate used in an instrument should be of optimum quality if the surface it is being used to measure is to be of high accuracy. Tests were performed and results show that, although many scatter plates would function, few were of the optimum quality necessary. These few were of the 180 grit group, using 35- and 30-s exposures, which are figures derived from calculations.			
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FABRICATION AND TESTING OF SCATTER PLATES FOR INTERFEROMETRY

INTRODUCTION

A scatter plate is the heart of a scatter plate interferometer, and the performance expected of this instrument is higher than ever because of the specifications of optical surfaces now being designed for space experiments and for solar and astrological investigations. The scatter plate interferometer, when functioning properly, is very accurate and inexpensive to fabricate. It requires little maintenance and alignment, but, if the scatter plate is not at its optimum, the full capabilities of the instrument cannot be realized.

This is a detailed report of the fabrication and testing of scatter plates for use in interferometry. The calculations furnished by Mr. Darryl Evans of the MSFC Astrionics Laboratory were used as a center point for the tests. The tests show these calculations to be very accurate.

DISCUSSION OF METHODS

Basically, the scatter plate is a double-exposed contact print of a random array of surface irregularities. These irregularities appear on the hand-ground surface of a piece of sheet glass that has been ground with a specific size grit. This sheet of glass is the master and can be used repeatedly for contact printing of scatter plates. The most important step when exposing is the rotation of the master 180 degrees after the first exposure period. The rotation of the master and the second exposure period will create on the film plate the necessary center of symmetry which is that characteristic that makes the scatter plate function in an interferometer.

An illustration of a scatter plate interferometer is given in Figure 1.

A two-part fixture was designed to hold the master and a film plate. The fixture allows the master to make contact with the film plate and provides an accurate means of rotating the master 180 degrees (plus or minus a few arc

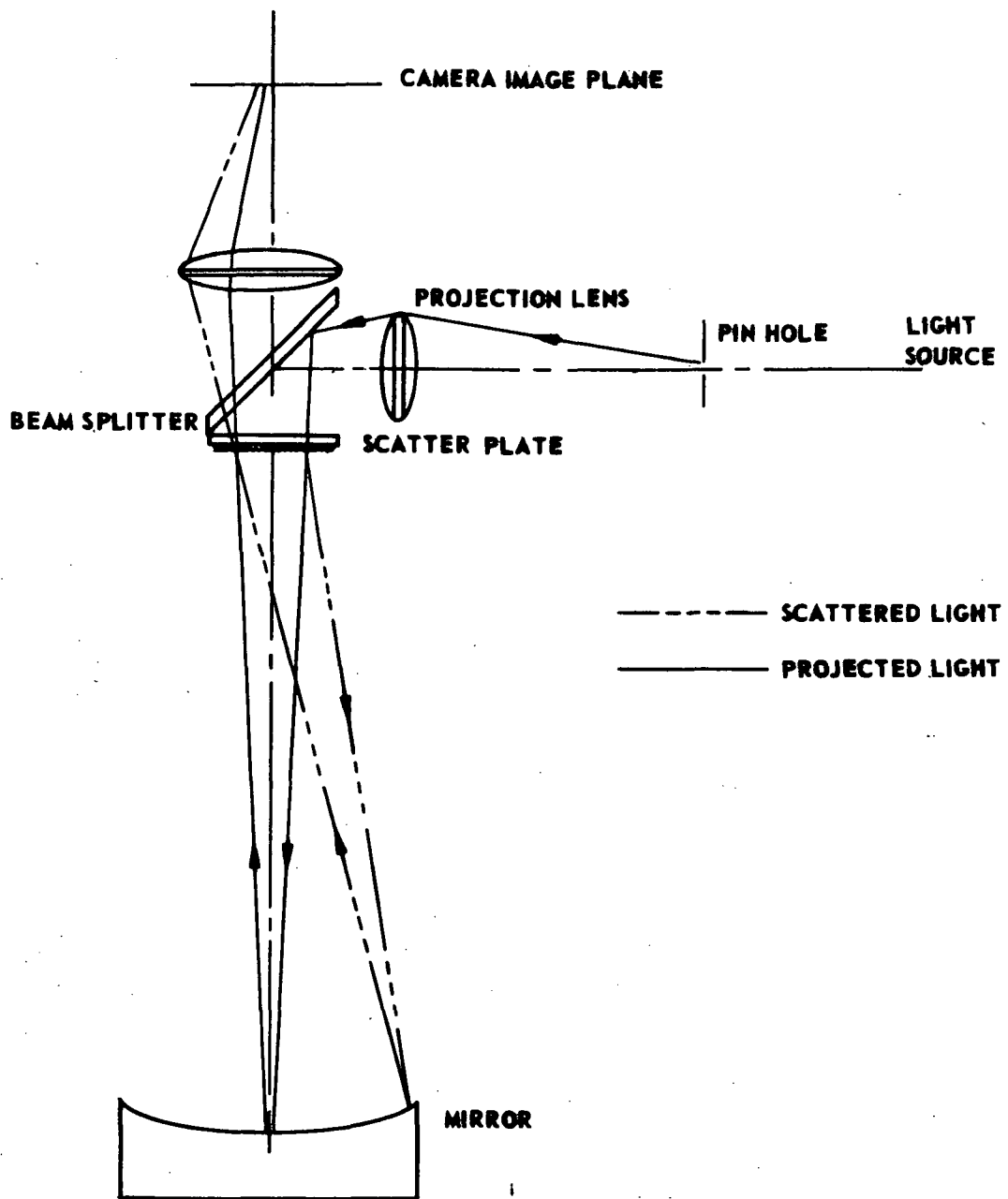
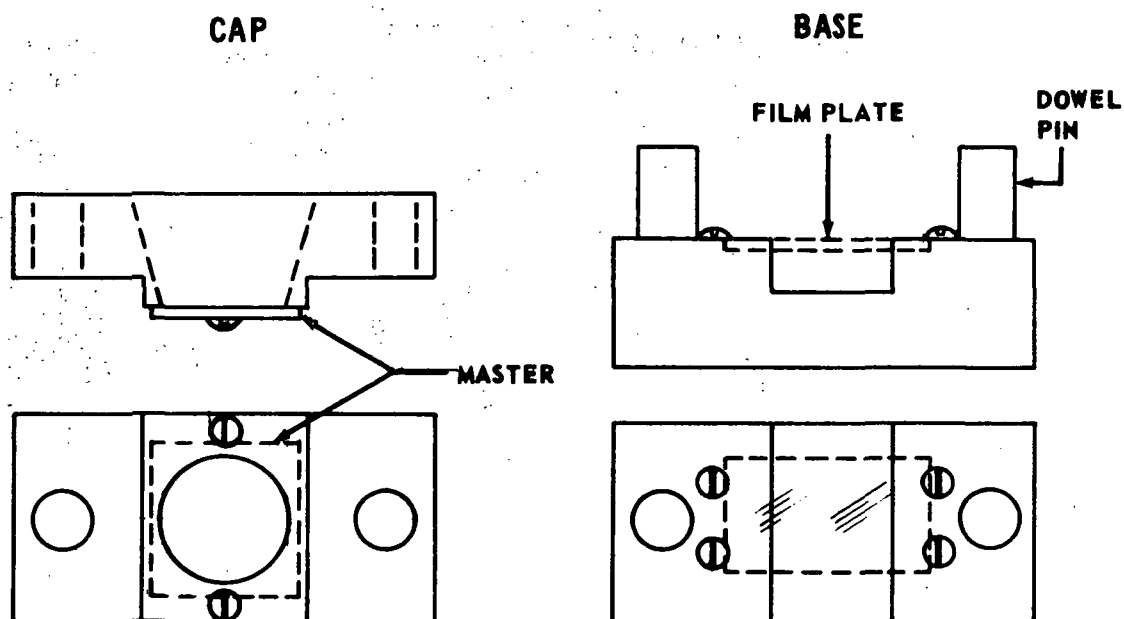


Figure 1. Scatter plate interferometer.

seconds). As can be seen in the sketch (Fig. 2), the fixture can be easily fabricated with two plates of metal aligned with each other by dowel pins. The base has a recess to accept and center a film plate which is held by four screw heads. The emulsion side of the film plate should be turned upward. The cap has two screws to hold the master which is mounted in such a way that the ground surface will make contact with the film plate when the cap is positioned over the dowel pins.



NOTE. THE WIDTH AND LENGTH OF THE MASTER SHOULD BE SUCH AS TO KEEP SCREWHEADS FROM PREVENTING THE MASTER AND FILM PLATE MAKING CONTACT.

Figure 2. Two-part fixture to hold master and film plate.

Without some visual aid, the center of symmetry of a scatter plate could not be found easily. This would make alignment of an interferometer with a mirror very difficult. To provide such an aid a V was put on the ground surface of the master with the point of the V at its physical center. This V can be made with a sharp pencil, with a fine ball point pen, or by etching,

which lasts longer. The V has three functions: (1) to center the master on the cap, (2) to tell if the film plate was exposed properly (the rotation of the master and the second exposure will transform the V into an X), and (3) to serve as a visual means to bring into coincidence the center of symmetry of the scatter plate and the center of symmetry of the return wave front from the optical surface being measured.

Mounting and centering the master on the cap was performed as follows. The base was clamped to the adjustable table of a toolmaker's microscope and the cap was positioned over the dowel pins so that the master would be on the top (upside down from the normal exposing position). The master was then centered between the dowel pins by rule measurements and clamped loosely with the two screws. The table was adjusted so that the V was in coincidence with the crosshair of the scope and the dial readings on the table were then recorded. The cap was rotated 180 degrees, and the V was again brought into coincidence with the crosshair by adjusting the table and the new dial readings were then recorded. One-half of any error in both planes was calculated and the table was adjusted so that the crosshair was at the calculated center of rotation. The master was moved so that the V was in coincidence with the crosshair and was then clamped securely. At this stage, if the master was considered to be optimum, it was secured permanently with an epoxy cement and the screws were removed.

When the master had been centered on the cap, the fixture was ready for use. An Omega Pro Lab D-6 4 by 5 enlarger with an f:1.56, 105 mm lens was used to expose the plates in the fixture. The fixture was centered in the diverging light field which was approximately 15 cm in diameter at the fixture position. The enlarger was operated through an electric timer that ensured equal exposure times on each plate. With the cap removed from the fixture, a film plate with the emulsion side up was inserted under the heads of the loosened screws on the base and into the recess. The cap was positioned over the dowel pins and the first exposure was made. A red safe light was used in the dark room when using Kodak high-resolution plates and, as a reminder to rotate the cap after the first exposure, a piece of masking tape that could be seen in the red light was placed on one end of the cap. A second exposure of equal duration was made after making the first exposure and rotating the cap. Several plates were exposed and processed at one session.

The photographic process was as follows:

1. Developer — Kodak D19 or HRP for 3 min.
2. Chromium bleach for 3 min.

3. Stop bath for 30 s.
4. Rapid fixer for 6 min.
5. Wash for 30 min.

It was found that the best method was to remove the plates from the wash one at a time and to immediately blow the plate dry with air; this helped prevent streaking. Pertinent data such as the grit size of the master, exposure time, etc., were inked in the corners of the plates on the emulsion side after drying.

Testing of the plates was done in a vertical measuring tower using an F/4, 61-cm uncoated spherical mirror with an accuracy of $\lambda/10$ or better. Two light sources were used to illuminate the interferometer: (1) an Ealing white light source, and (2) a 1 mW spectra physics HE-NE laser. Both sources were piped to the interferometer through an optical fiber bundle. The white light was used to align the interferometer with the mirror and, when a fringe pattern could be seen, the laser was introduced into the system. The laser gave better contrast for visual and photographic evaluation.

Table 1 gives the results of the visual evaluation of all plates made with regard to the general qualities of the scatter plates.

Photographic tests were made of all scatter plates through the interferometer. This was done using a Nikon camera with an F/1.4 lens, 5.8-cm FL, and Tri-X-Pan film. With the equipment used, the best exposure times were one-fifteenth and one-thirtieth of a second. When processed, the film images were projected onto a screen for evaluation. Table 2 lists the exposure times of the plates designated as good, and also the exposure times used with the Nikon.

CONCLUSIONS

From our tests, using the equipment described, it was determined that contrast was relative to the number of fringes and that the number of fringes was relative to the combination of the grit size of the master and the exposure time used on the film plate.

TABLE 1. VISUAL EVALUATION OF SCATTER PLATES

Master Grit Size	Exposure Time, s	Area of Mirror Illuminated	Max. No. of Fringes	Contrast	Remarks	Plate No.
50	40	All	10-12	Fair	No. 4 & 5: difficult to pick up return x. An ink spot was put in center of x on the plate.	1
	35	All	12-14	Good +		2
	30	All	12-14	Good		3
	25	All	8-10	Good		4
	20	All	None	-		5
100	40	All	8-10	Fair	No. 4-5-6: same return image problem as in 50 grit group.	1
	35	All	8-10	Fair		2
	30	All	18-20	Good +		3
	25	All	16-18	Good		4
	20	All	10-12	Fair		5
	15	All	10-12	Fair		6
180	35	All	18-20	Good +	No. 3-4-5: same return image problem as above.	1
	30	All	18-20	Good +		2
	25	All	18-20	Good		3
	20	All	14-16	Good		4
	15	All	8-10	Fair		5
220	30	All	14-16	Fair	No. 2-3-4-5: same return image problem as above.	1
	25	All	14-16	Fair		2
	20	All	16-18	Good		3
	15	All	16-18	Good +		4
	10	All	8-10	Fair		5

TABLE 2. EXPOSURE TIMES OF GOOD PLATES AND OF NIKON FILM

Master Grit Size	Plate Number	Plate Exposure Time, s	Film Exposure Time, s
50	2	35	1/15
	3	30	1/15
	4	25	1/15
100	3	30	1/15
	4	25	1/15
180	1	35	1/30
	1	35	1/15
	2	30	1/30
	2	30	1/15
	3	25	1/30
	4	20	1/30
	4	20	1/30
220	3	20	1/30
	4	15	1/30

The configuration of the mirror being measured has a bearing on the choice of a scatter plate. As the number of fringes obtainable on the mirror increases, the area that can be scanned on a microdensitometer becomes smaller, and thus the surface errors can be plotted and located more accurately.

For these reasons, the optimum choices of the scatter plates fabricated are of those made with the 180-size grit master using the 35- and 30-s exposure times.


APPROVAL

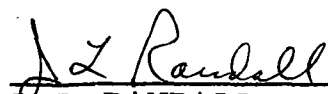
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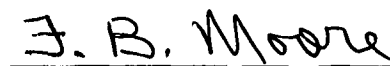
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